Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 3; January-March, 2015 pp. 214-218

http://www.krishisanskriti.org/jceet.html

Copper Slag, A Solution and an Alternative to River Sand and in Concrete Manufacturing

Raja Abhishek[1], Krishna Murari[2], Atul Singh[3] and Sachin Gangwa[4]

[1,2,3,4]CE UG Scholar, JUET Add- Jaypee University of Engineering & technology, A.B. Road, P.B. No. 1, Raghogarh, Dist- Guna – 473226
[2](CE), JUET
[3]CE UG Scholar, JUET
[4]CE UG Scholar, JUET
E-mail: [1]raja.abhishek42@gmail.com, [2]k.murari@rediffmail.com, [3]tomaratul791@gmail.com, [4]gangwarsachin@yahoo.com

Abstract—*Copper slag is an industrial by-product, produced during manufacture of copper. Due to depletion & thereby scarcity of natural resources seems to be a problem for successive generations, it is needed to search the alternatives of natural sand (river sand). This paper presents the results and comparison between the properties of conventional concrete & concrete made by partial replacement of river sand by copper slag. For this research M20 and M40 grade of concrete were used. And the replacement of natural sand by copper slag was 20%, 30%, 40% and 50%. Maximum compressive strength was found at 40% replacement level at 7 days and 28 days for both grades. Increase in compressive strength can be up to 41% from that of the control mix design concrete.*

1. INTRODUCTION

Concrete, is the second most used material for construction purpose in the world after steel. It is a composite material made up of various materials such as cement or cementitious material, water, coarse aggregates, fine aggregate etc. Now a days in developing countries like India, is going to need concrete in bulk for consistent development. For conventional methods natural resources are being used as fine aggregate (river sand), which causes depletion of natural resources thereby creating hazardous ecological situation like unbalancing environment. So protecting natural resources has been a major concern of the day. It can be only done by banning sand mines and utilization of industrial waste product or by products as fine aggregate. It will result profitable for both waste dumping as well as reduced cost of construction. Previously many researchers have found that industrial wastes have resulted better properties of concrete. In this paper, we have replaced river sand by copper slag by 20%, 30%, 40% and 50% respectively to find the variations in 7days & 28days compressive strengths of M20 & M40 grade of concrete.

2. PHYSICAL AND CHEMICAL PROPERTIES OF COPPER SLAG

Copper slag is black glassy and granular in nature as shown in figure1. And similar particle size as that of river sand so it can be used as a replacement material for FA. The bulk density of the slag varies between 1.7g/cc to 1.9g/cc, the specific gravity is approx. 3.68 (slightly lesser for river sand). The hardness of slag is 6-7 in Moh scale (equal to gypsum), an ingredient of PPC). The pH of the aq. solution varies from 6.6 to 7.2. The limiting water soluble chloride content as per IS 11127 is 11ppm. The slag is conforming to the above standards. The free moisture content present in slag was found to be less than 1%.The chemical composition of slag is presented in Table1 presence of silica in slag is about 26% which is desirable since it is one of the constituents of the natural fine aggregate used to normal concreting operations. The presence of copper, alumina, sulphate in the slag were only traces and hence not harmful.

Table 1: Composition of Copper Slag

S. no.	Chemical compounds	% of compounds (approx.)
1.	Fe_2O_3	69
2.	SiO_2	26
3.	Al_2O_3	0.22
4.	CaO	0.15
5.	MgO	0.2
6.	Na_2O	0.58
7.	K_2O	0.23
8.	Mn_2O_3	0.22
9.	TiO_2	0.41
10.	CuO	1.2
11.	Insoluble residue	14.88

Properties of mixed Fine aggregate at all replacement levels are almost similar to that of the river sand.

Fig. 1: Copper Slag

3. EXPERIMENTAL PROGRAM

For our research work, an experimental program was setup. Concrete of grade M20 & M40 were designed as per Indian standard. Then cubes (150mm*150mm*150mm) were casted in two triplets (one for 7 days & another for 28 days) for each grade and all replacement levels. They were cured in normal conditions as per codal provisions. Then samples were tested for compressive strength. As one can infer other strengths by compressive strength, so only compressive strength is calculated.

Mix Design Details

Cube samples of grade M20 & M40 were designed as per IS: 483 containing different proportions of copper slag as partial replacement of river sand. Different mix proportions are given below in Table2 & Table3.

Table 2: Mix Design Details for M20 Grade Concrete

Mixes	Raw material in kg/m^3				
	Cement	Sand	Copper Slag	Coarse Agg.	w/c ratio
0% CS	308	896.6	0	1107	0.55
20% CS	308	717.32	179.32	1107	0.55
30% CS	308	627.62	268.98	1107	0.55
40% CS	308	537.96	358.64	1107	0.55
50% CS	308	448.30	448.30	1107	0.55

Table 3: Mix Design Details for M40 Grade Concrete

Mixes	Raw material in kg/m^3				
	Cement	Sand	Copper Slag	Coarse Agg.	w/c ratio
0%CS	384	804	0	1111	0.4
20%CS	384	643.2	160.8	1111	0.4
30%CS	384	562.8	241.2	1111	0.4
40%CS	384	482.4	321.6	1111	0.4
50%CS	384	402	402	1111	0.4

Cube compressive strength tests and results

Compressive strength of cube specimen at 7days and 28days were illustrated in table & table. The procedures were as per IS standards shown in Figure2.

Fig. 2: Test procedure for compressive strength test

The results are illustrated in Table 4 & Table 5 for M20 & M40 respectively for 7 days strength.

Table 4: compressive strength of M20 in 7days

S. No.	% replacement by CS	slump (MM)	Load (N/MM2)	Strength (N/MM2)	Avg. strength (N/MM2)	% increase
1	0	100	387.6	17.23		
2	0	100	385.4	17.13	17.30	0
3	0	100	394.7	17.54		
4	20	110	429.2	19.08		
5	20	110	426.5	18.96	18.94	9.48
6	20	110	422.8	18.79		
7	30	120	436.6	19.40		
8	30	120	439.5	19.53	19.45	12.43
9	30	120	436.8	19.41		
10	40	110	475.8	21.15		
11	40	110	480.5	21.36	21.31	23.20
12	40	110	482.4	21.44		
13	50	90	453.7	20.16		
14	50	90	456.2	20.28	20.14	16.41
15	50	90	449.5	19.98		

Table 5: Compressive Strength of M40 in 7days

S. No.	% Replacement of NS by CS	Slump (MM)	Load (KN)	Strength (N/MM^2)	Avg Strength (N/MM^2)	% increase
1	0	100	708.6	31.49		
2	0	100	689.3	30.64	31.31	0
3	0	100	715.2	31.79		
4	20	110	710.8	31.59		
5	20	110	739.4	32.86	33.31	6.40
6	20	110	798.5	35.49		
7	30	110	737.1	32.76		
8	30	110	806.5	35.84	34.31	9.59
9	30	110	772.4	34.33		
10	40	90	821.1	36.49		
11	40	90	805.2	35.79	35.76	14.22
12	40	90	787.6	35.00		
13	50	90	752.7	33.45		
14	50	90	693.2	30.81	31.64	1.04
15	50	90	689.5	30.64		

Results of 28days M20 and M40 grade concrete mix are illustrated in Table6 & Table7 respectively.

Table 6: Compressive Strength of M20 in 28days

S. No.	% Replacemnt of NS by CS	Slump (MM)	Load (KN)	Strength (N/MM^2)	Avg. Strength (N/MM^2)	% increase
1	0	100	596.7	26.52		
2	0	100	599.7	26.65	26.68	0
3	0	100	604.6	26.87		
4	20	110	798.4	35.48		
5	20	110	799.7	35.54	35.58	53.27
6	20	110	803.7	35.72		
7	30	120	807.7	35.90		
8	30	120	810.9	36.04	35.97	41.03
9	30	120	809.3	35.97		
10	40	110	815.7	36.25		
11	40	110	818.7	36.39	36.12	41.01
12	40	110	803.8	35.72		
13	50	90	737.2	32.76		
14	50	90	758.3	33.70	32.56	30.98
15	50	90	702.4	31.22		

Table 7: Compressive Strength of M40 in 28days

S. No.	% Replacemnt of NS by CS	Slump (MM)	Load (KN)	Strength (N/MM^2)	Avg. Strength (N/MM^2)	% increase
1	0	100	1050	46.67		
2	0	100	1011	44.93	45.99	0.0
3	0	100	1043	46.36		
4	20	110	1088	48.36		
5	20	110	1104	49.07	48.71	23.4
6	20	110	1096	48.71		
7	30	120	1159	51.51		
8	30	120	1144	50.84	51.41	30.2
9	30	120	1167	51.87		
10	40	130	1172	52.09		
11	40	130	1169	51.96	52.25	32.3
12	40	130	1186	52.71		
13	50	130	1120	49.78		
14	50	130	1126	50.04	50.15	27.0
15	50	130	1139	50.62		

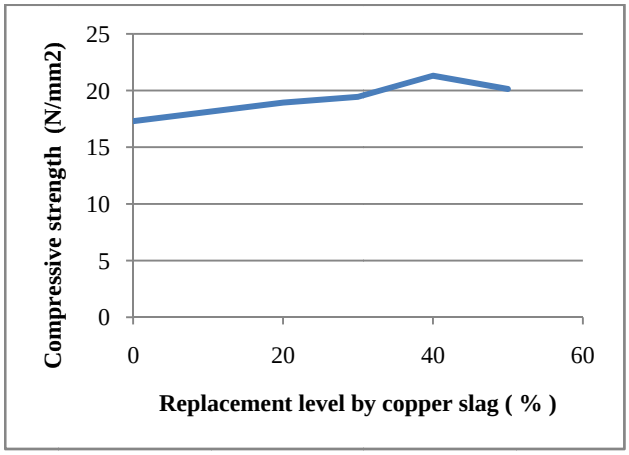

Fig. 3: compressive strength of M20 grade concrete in 7days

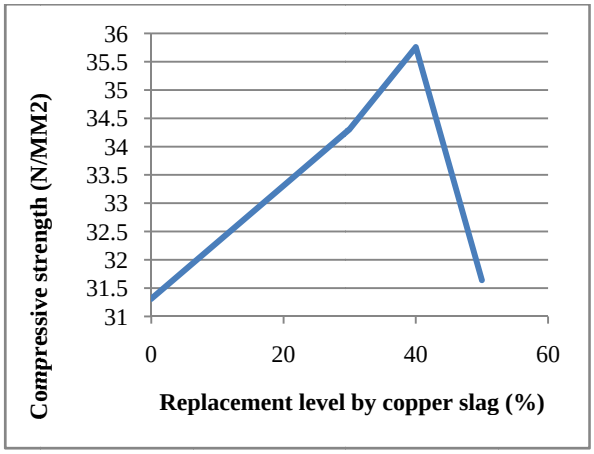

Fig. 4: Compressive strength of M40 grade concrete in 7days

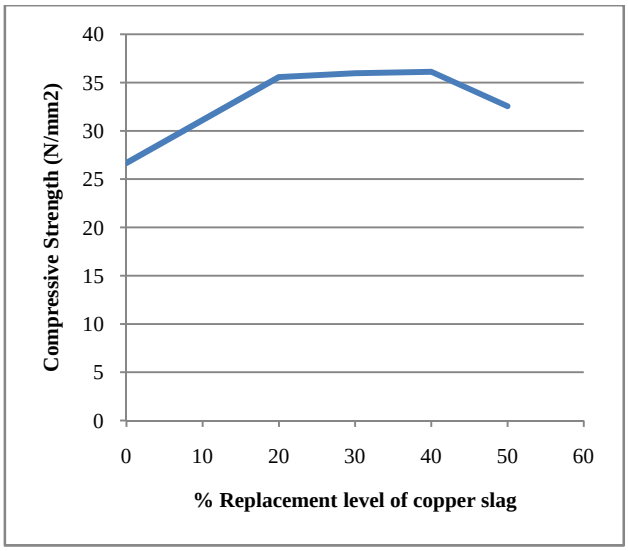

Fig. 5: compressive strength of M20 grade concrete in 28 days

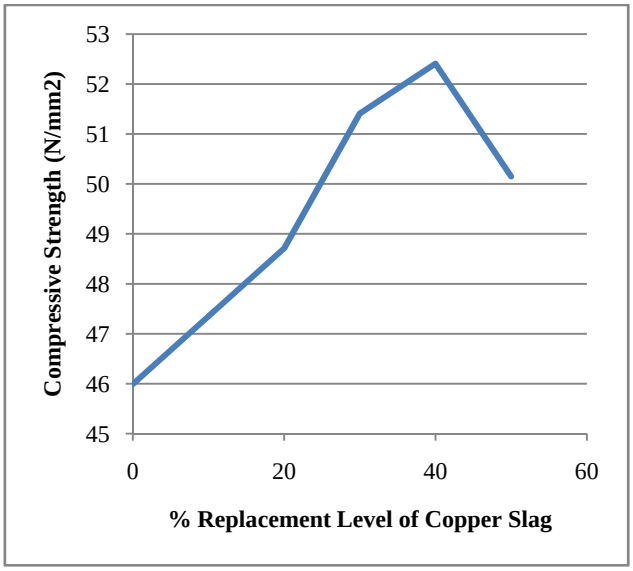

Fig. 6: Compressive Strength of M40 Grade Concrete in 28days

4. MATERIALS USED

Cement

Portland Pozzolana cement of specific gravity 3.65 and fineness modulus of 4.62% was used.

Coarse aggregate

Crushed angular basalt of 10mm and 20mm sizes were used in 40:60 proportions.

Copper Slag

Copper slag of specific gravity 3.68 was used.

Test specimen

Test specimen of (150mm*150mm*150mm) dimensions were casted.

5. DISCUSSIONS OF RESULTS

Quantities of material

Table 2 and table 3 gives the quantities of materials used for M20 & M40 grade of concrete.

Compressive strength

From the results of our experimental investigations we analyzed that up to 40% replacement of natural sand by copper slag, the compressive strength increased. However for mixes with 50% replacement compressive strength decreased rapidly. For M20 grade mix concrete with 40% of copper slag at 7days, 28days compressive strength were 21.31N/mm^2 and 36.12N/mm^2 compared with 17.30N/mm^2 and 26.68N/mm^2 for the control mix. And for M40 grade mix concrete with 40% of copper slag at 7days, 28days compressive strength were 35.76N/mm^2 and 52.25N/mm^2 compared with 31.31N/mm^2 and 45.99N/mm^2 for the control mix.

For M20 grade concrete with 50% of copper slag replacement the 7days and 28days compressive strengths are 20.14N/mm^2 and 32.56N/mm^2. Whereas, for M40 grade concrete with 50% of copper slag replacement the 7days and 28days compressive strengths are 31.64N/mm^2 and 50.15N/mm^2. These variations are shown in Fig. 3, 4,5 & 6.

Copper Slag has a lower water absorption capacity when compared with Sand. The lower water absorption capacity causes increased free water content there by decrease in Compressive Strength.

6. CONCLUSIONS

Copper Slag behaves similar to River Sand, for its use as fine aggregate (partially or in blending) in Concrete mixes. Addition of Copper Slag in Concrete increases the density, thereby the self-weight of Concrete. The results showed that the workability of Concrete increased substantially with increase of Copper Slag content in the concrete mixture due to the low water absorption, coarser (in nature than sand) and glassy surface of Copper slag, thereby the Strength properties also improved. The Compressive Strength of Concrete is comparable to the control mix up to 40% of Copper Slag substitution, but they decrease with a further increase in Copper Slag contents (due to the increase of free water content in the mix). Compressive Strength of Copper Slag admixture Concrete, increased due to high toughness of Copper Slag. Replacement of Copper Slag as fine aggregate in concrete mixes reduces the cost of concrete production. The utilization of Copper Slag in Concrete production provides additional environmental as well as effective waste management technique for all the related Industries.

7. ACKNOWLEDGEMENT

The authors wish to acknowledge Jaypee University of Engineering and Technology, Guna and Sterlite Industries (India) Ltd.,Tuticorin, India for providing all the facilities for carrying out this research work.

REFERENCES

[1] D. BRINDHA and S. NAGAN (2010): Utilization of Copper Slag as a Partial Replacement of Fine Aggregate in Concrete, International Journal of Earth Sciences and Engineering ISSN 09745904.

[2] Suresh Reddy S, Kishore Kumar M (2013): Utilization of Copper Slag as a Partial Replacement of Fine Aggregate in Concrete, International Journal of Mechanical Engineering and Computer Applications, Vol 1, Issue7, December2013, ISSN 2320-6349.

[3] Dr. T.Ch.Madhavi (2014): COPPER SLAG IN CONCRETE AS REPLACEMENT MATERIAL, INTERNATIONAL JOURNAL OF CIVIL ENGINEERING AND TECHNOLOGY (IJCIET), ISSN 0976 – 6308 (Print) ,ISSN 0976 – 6316(Online).

[4] Tamil Selvi P*, Lakshmi Narayani P and Ramya G (2014): Experimental Study on Concrete Using Copper Slag as Replacement Material of Fine Aggregate, Civil & Environmental Engineering research article.

[5] Jayapal Naganur, Chethan B. A. (2014): International Journal of Research (IJR) Vol-1, Issue-8, September 2014 ISSN 2348-6848.

[6] MANGURIU, G.N., KARUGU, C.K., OYAWA, W.O., ABUODHA, S.O. and MULU, P.U.: PARTIAL REPLACEMENT OF NATURAL RIVER SAND WITH CRUSHED ROCK SAND IN CONCRETE PRODUCTION, GLOBAL ENGINEERS & TECHNOLOGISTS REVIEW.